Superabsorbent Polymer in Agriculture Industry for Plant Protection

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

by

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It is the work that is expected to be carried out under the supervision of **Dr. Arpit Sand**.

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ABSTRACT

In this synopsis many research papers are reviewed behind the innovation of application of super absorbent polymer in agronomical procedure. Mechanism behind the application in agriculture industry is water retention capacity, swelling capacity, soil conditioner for green and sustainable agriculture equipment's. Super absorbent polymers (SAPs) are three dimensional, cross linked, hydrophilic hydro gels. Different techniques are used for the polymerisation process for preparation of graft co polymers like SEM (Scanning Electron microscopy), FTIR (Fourier Transform Infrared Spectroscopy). The grafted copolymer is customised according to the pH sensitivity smelling behaviour of soil and temperature of region. And the polymer is amalgamation of amending of a fixed ratio of hydrogel with some synthetic already tested and biodegradable polymer. The use of SAP Super absorbent polymer is due to its bio compatible, bio degradable and renewable nature.

The combinations of both natural and synthetic polymer will often greater potential to the future agronomy in a better and beneficiary way. Some mathematical or chemical equation which are already proposed are used for the testing of swelling capacity and bulk density in soil on some specific plants.

Keywords; Superabsorbent polymer-SAP,biocompatible, hydrogel,Agronomy,Swelling Capacity ,Graft copolymer

Introduction

In India and other countries of earth due to variable weather conditions and availability of water or scarcity of water leads to formulation of synthetic polymer.

Superabsorbent are cross linked hydrogel and it has high water holding capacity and high swelling capacity.[1] The agriculture industry suffers due to soil pollution, water pollution and temperature and pH of soil and Industrial waste and drought conditions. So to minimize those efforts we can apply some techniques like uses of Superabsorbent polymer.

As per Super absorbent polymer properties, they are used in hygienic purpose for female sanitary napkins, baby diapers. [2-5]

Super absorbent polymer are smart hydrogels[6] due to their different features like

A) pH Sensitivity
B) Heat resistant
C) Reflux towards electric field
D) Non toxicity
E) Biodegradable
F) Economically and environment sustainable

Super absorbent polymer are also used in wrapping inside communication cable as it absorb water from environment and protect the wiring.

The application of Superabsorbent polymers due to their amending or grafting with cross linkers and some synthetic polymer increased towards drug delivery system, tissue engineering, food industry, agronomical procedure[7-10]. Generally superabsorbent polymer are toxic in nature[11] that shows hydrophilic nature. We will graft these Superabsorbent polymers with some other polysaccharides to make it better for each type of soil and in each weather conditions. Some polysaccharides used are chitosan, gum acacia, guar gum, icatonic acid.

Grafted copolymer are of wider application due to their fascinating properties like soil conditioner , non –toxic , bio- degradable, retention capacity, and also promote growth of plant and crop production.[12-15]

After grafting super absorbent polymer will also show enhance in properties like permeability, water use efficiency, density, texture, evaporation rate with leaching and seepage in ground water.

The application of super absorbent polymer also varies according to the external forces like, pH, temperature, weather conditions, electric and magnetic field in that specific area[16].

Due to toxic part of Super absorbent polymers it absorb water and if Super absorbent polymers are covalent or hydrogen bonding polymer than it will be used for concrete and mortar as it is highly strong.

Cotton is cellulose used for porous resource in ancient time. Witchterle and Lim prepared this in 1960 for the first time.[17]

Many chemical methods or reaction came into formulation for the preparation of different type of Super absorbent polymers, some which are mentioned below

1) Toxic radiation technique
2) Free radical polymerization technique
3) Cross linking technique

Super absorbent polymers provide the fuelling technique in agronomy due to its root adhesion property[18-19].

Reaction structure for the proposed mechanism

Polysaccharides + Cross linking agent + Synthetic Polymer ----------→ Superabsorbent polymers 3

Different hydrogels according to different cross linking agent and different synthetic polymer addition behaves differently and shows various changes in there swelling capacity, water holding capacity, degradation capacity[20].

The hydrophilic nature of Superabsorbent polymers are due to some common functional groups like [$-SO_3H$, -OH, $-NH_2$, -COOH, $-CONH_2$]. [21]There is an observation and a theory proposed for the swelling mechanism as if the cross linking agent is not present then Super absorbent polymers have no use for any swelling mechanism. But if it is present then Swelling force and expansion force and contraction force comes into picture up to an equilibrium condition and the changes according to the temperature, pH, water content conditions.[21-24]

Superabsorbent polymers are also used to enhance the crop production as per needs like in drought and intensive crop conditions.

In conditions like evaporation, water seepage or low rain or water scarcity, the bio polymer hydrogels acts as human that keeps the soil humid, towards a greener approach [25-26].

Literature Review

After going through many research papers, I experienced a lot of observation regarding superabsorbent polymer in different industries like drug delivery, agronomy Industry, tissue engineering, bio engineering etc.[27] Mostly hydrophilic polymers with polar groups attached are used as water retention agent or as soil conditioners. Super absorbent obtained by waste of shellfish is also done.[28-29] There is a research gap of some Super absorbent polymers on scarcer exploration in agronomy and its potential in the agriculture Industry. The non biodegradable nature of the Superabsorbent polymers also a reason behind further innovative ideas to make it possible for environmental friendly or biodegradable [30-33].

SAH (Superabsorbent hydrogel) with sodium salt acts as soil conditioner and water holding capacity was determined by some plantation technique [34].

This research work will get progress towards graft co polymerisation to produce gelatinized starch of acrylic acid, chitosan provide eco friendly element for commercial purpose also it uses be formulated with some Super absorbent polymers resin to increase H_2O retention capacity [35-37].

Ricardo et al proposed the H_2O amalgamation of textiles and fibres. Super absorbent polymers based on natural polymer grafted with synthetic polymer for further promising and potential research. Also it will be used in electrochemistry as some modified glassy carbon electrode (GCE) for detection in electrochemical sensor.

Description of broad research topic

The Three dimensional cross linked superabsorbent hydrogels are ionic polymers. So that they can swell according to the mixing polysaccharides and that leads to high swelling capacity and which leads to application of that specific polymer in different industry agronomy industry is targeted to be more easy and cost effective after this.

Obectives of this research

1) To study the synthesis of different Super absorbent polymers by monomers like acrylic acid or methacrylic acid
2) Polysaccharides like carbonyl methyl tamarind derivative, gelatine, cellulose, guar gum be synthesized by solution polymerisation
3) To study the properties by FTIR (Fourier Transform Infrared Spectroscopy), SEM (Scanning electron microscope) and CRC (Centrifugal Residual Capacity)
4) To study swelling capacity and water holding capacity by using FAC (Free absorption Capacity) and AUL (Absorption under load).
5) To study the change in properties by varying the nature of salt.

Experimental procedure

1) Neutralization of monomer using a spong base in present atmosphere without disturbing the Neutralization process
2) Free radical polymerization reaction will takes place to produce Superabsorbent polymers
3) Initiator, cross linker will be added for polymerisation
4) Some non inflammable alcohol will be used for drying process in oven at specific temperature.

Assesment Criteria

1)**Swelling assessment**

Gravimetric measurement will be studied for swelling behaviour of hyldrogels

Equilibrium Swelling ratio specified by

$ESR = (W_E - W_D)/ W_D$

Where W_E= At equilibrium Hydrogel weight

W_D = Weight of dehydrated hydrogel

Conditions are like temperature and pH are varied for observation of swelling capacity of hydrogels and are noted and calculated for further research.

2) **Degradable capacity study**

It is calculated by formula

$$RDC\ \% = \frac{\text{weight of dry hydrogel X 100}}{\text{Weight of initial dry content of Hydrogel}}$$

Where RDC is Residency Dry Content

3) **Maximum water holding**

Capacity- Three or four samples will be taken with control sample with properly dried sample dried by filter paper to avoid error and allow to stand to absorb upto its maximum capacity by overnight including all external factors. So formula used to calculate is

4. MWHC (Maximum water holding capacity)

MWHC= [(weight of beaker after absorbing water)- (wt of dried soil)
+wt of empty beaker + weight of wet filter paper]

5. Soil Density and porosity calculations

Porosity percentage is calculated by following method

Porosity (%) = [1 – *BD/ PD*] X 100.

Where BD = Bulk density PD = Particle density

Effect of used chemicals like

Initiator, cross-linker, biopolymer will be also be studied and the polymerized product will undergo through FTIR and SEM to further conclusion for its use.

Expected outcomes will be

1) To produce and publish quality containing original and useful research paper.
2) To produce Super absorbent hydrogel, which is bio degradable and cost effective
3) For the synthesis of Superabsorbent polymer's by applying cost effective experimentation technique
4) To produce soil conditioner used in agronomy industry.

References

1. Mignon A,Belie DN, Dubruel P, Vlierberghe VS, *Superabsorbent polymers: A review on the Characteristics and application of synthetic, polysachride-based, semi-synthetic and 'smart' derivatives.* European Polymer Journal, 2019. 117: 165-178

2. Sand A and Vyas A, *Superabsorbent polymer based on guar gum-graft-acrylamide: synthesis and characterization*. J Polym, 2020. Res 27: 43

3. Li X, He JZ, Hughes JM, Liu YR, Zheng YM, *Effects of super-absorbent polymers on a soil–wheat (Triticumaestivum L.) system in the field*. Appl Soil Ecol, 2014. 73:58–63

4. Laftah WA, Hashim S, Ibrahim AN, *Polymer hydrogels: A review.*Polym-PlastTechnolEng, 2011. 50:1475–1486

5. Buchholz FL and Graham AT, *Modern Superabsorbent Polymer Technology. Wiley, Newyork*(1997)

6. Kazanskii KSand Dubrovskii SA,*Chemistry and Physics of Agricultural Hydrogels.*Advances in Polymer Science,1992. 104**:** 97-133

7. Kiatkamjornwong S and Suwanmala P *partially hydrolyzed polyacrylamide-poly(N-vinylpyrrolidone) copolymers as superabsorbents synthesized by gamma irradiation.* Journal of Applied Polymer Science,1998. **68:** 191-203

8. Kiatkamjornwong S and Wongwatthanasatien R, *Superabsorbentpolymer of poly[acrylamide-co-(acrylic acid)] by foamed polymerization. I. Synthesis and water swelling properties.* Macromolecular Symposia, 2004. **207:** 229-240.

9. Kidwell DA, *Superabsorbent Polymers - Media for the Enzymatic Detection of Ethyl-Alcohol in Urine.* Analytical Biochemistry, 1989. **182:**. 257-261.

10. Kilian W and Fanta J, *Degradation of forest sites and possibilities for theirrecovery.* Ecological Engineering, 1998. **10:**. 1-3.

11. Kim JH, Lee JH, and Yoon SW, *Preparation and swelling behavior of biodegradable superabsorbent gels based on polyaspartic acid.* Journal of Industrial and Engineering Chemistry, 2002. 8: 138-142.

12. Kimura T and Hikichi S, *pH-Dependence of the lower critical solution temperatures of random copolymers of N-isopropylacrylamide and itaconic acid.* KobunshiRonbunshu, 2000. 57: 730-733.

13. Kitch BT, Levy BD, and Fanta CH, *Late onset asthma - Epidemiology,diagnosis and treatment.* Drugs & Aging, 2000. **17:** 385-397.

14. Knaebel A, Rebre SR and Lequeux F, *Determination of the elasticmodulus of superabsorbent gel beads.* Polymer Gels and Networks, 1997. 5: 107-121.

15. Mechtcherine V, Reinhardt HW, STAR 225-SAP Application of Superabsorbent Polymers (SAP) in Concrete Construction; Springer Science & Business Media: Berlin, Germany, 2012.

16. Jensen OM, Hansen PF, *Water-entrained cement-based materials I. Principles and theoretical background.*Cem.Concr. Res., **2001**. 31: 647–654.

17. Jensen OM, Hansen PF, *Water-entrained cement-based materials II. Experimental observations.*Cem. Concr. Res., **2002**. 32: 973–978.

18. Dudziak L, Mechtcherine V, Hempel S, *Mitigating early age shrinkage of Ultra-High Performance Concrete by using Super Absorbent Polymers (SAP), Creep Shrinkage Durab*. Mech. Concr. Concr. Struct.,**2009**.847–853.

19. Kim JS, Schlangen E, *Super Absorbent Polymers to Stimulate Self Healing in Ecc. In Proceedings of the 2nd International Symposium on Service Life Design for Intrastructures (SLD2010)*, Delft, The Netherlands,2010. 849–858.

20. Van Tittelboom K, Snoeck, D, Wang J, De Belie N, *Most recent advances in the field of self-healing cementitious materials. In Proceedings of the ICSHM*, 4th International Conference Self-Healing Materials, Ghent, Belgium, 2013. 406–413.

21. Lee H, Wong HS, Buenfeld N, *Potential of superabsorbent polymer for self-sealing cracks in concrete.*Adv. Appl. Ceram, **2010**. 109: 296–302.

22. Tsuji M, Shitama K, Isobe D, *Basic Studies on Simplified Curing Technique, and Prevention of Initial Cracking and Leakage of Water through Cracks of Concrete by Applying Superabsorbent Polymers as New Concrete Admixture.* J. Soc. Mater. Sci. Jpn.,**1999**. 1308–1315.

23. Snoeck D, Van Tittelboom K, Steuperaert S, Dubruel P, De Belie N, *Self-healing cementitious materials by the combination of microfibres and superabsorbent polymers.* J. Intell. Mater. Syst. Struct., **2012**. 25: 13–24.

24. Snoeck D, *Superabsorbent polymers to seal and heal cracks in cementitious materials.* RILEM Tech. Lett.,**2018**. 3: 32–38.

25. Snoeck D, Steuperaert S, Van Tittelboom K, Dubruel P, De Belie N, *Visualization of water penetration in cementitious materials with superabsorbent polymers by means of neutron radiography.* Cem. Concr. Res,**2012**. 42: 1113–1121.

26. Monnig S, Lura P, *Superabsorbent Polymers—An Additive to Increase the Freeze-Thaw Resistance of High Strength Concrete.* Adv. Constr. Mater, **2007**. 351–358.

30. Khushbu, S.G. Warkar, N. Thombare, Zinc micronutrient-loaded carboxymethyl tamarind kernel gum-based superabsorbent hydrogels: controlled release and kinetics studies for agricultural applications, Colloid Polym. Sci. 2021 2997 299 (2021) 1103–1111,

31. Khushbu, S.G. Warkar, Potential applications and various aspects of polyfunctional macromolecule- carboxymethyl tamarind kernel gum, Eur. Polym. J. 140 (2020), 110042,

32. S. Nangia, S. Warkar, D. Katyal, A review on environmental applications of chitosan biopolymeric hydrogel based composites, J. Macromol. Sci. Part A Pure Appl. Chem. 55 (2018) 747–763,

33. Q.-Z. Yan, W.-F.Zhang, G.-D.Lu, X.-T.Su, C.-C.Ge, Frontal copolymerization synthesis and property characterization of starch-graft-poly(acrylic acid) hydrogels, Chem. A Eur. J. 11 (2005) 6609–6615,

34. H.A. Abd El-Rehim, E.-S.A. Hegazy, H.L. Abd El-Mohdy, Effect of various environmental conditions on the swelling property of PAAm/PAAcK superabsorbent hydrogel prepared by ionizing radiation, J. Appl. Polym. Sci. 101 (2006) 3955–3962, .

35. A.R. Fajardo, M.B. Silva, L.C. Lopes, J.F. Piai, A.F. Rubira, E.C. Muniz, Hydrogel based on an alginate-Ca2+/chondroitin sulfate matrix as a potential colon-specific drug delivery system, RSC Adv. 2 (2012) 11095–11103, .

36. W.E. Hennink, C.F. van Nostrum, Novel crosslinking methods to design hydrogels, Adv. Drug Deliv. Rev. 64 (2012) 223–236,

37. Y. Yue, X. Wang, J. Han, L. Yu, J. Chen, Q. Wu, J. Jiang, Effects of nanocellulose on sodium alginate/polyacrylamide hydrogel: mechanical properties and adsorption-desorption capacities, Carbohydr. Polym. 206 (2019) 289–301,

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